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THE HYGROTHERMOAEROGRAPH—CONSTRUCTION AND FIRE MANAGEMENT APPLICATIONS

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ABSTRACT

Conventional hygrothermographs can be modified as described here to record windspeed along with temperature and relative humidity. The fire-weather record resulting from the modification has several fire management applications, as demonstrated in field use.

Fire management skill is acquired through understanding of the changing relations of weather, fuels, and fire behavior. In planning the control of wildfires and the conduct of prescribed fires, fire managers are dealing with a dynamic atmosphere of varying windspeed, relative humidity, and temperature. Continuous monitoring of these weather parameters can provide essential data for guiding fire management decisions. A readily available and portable monitor is the hygrothermograph. Its value as a tool for fire management has long been recognized (Hofman and Osborne 1923). The limitations of hygrothermographs as weather recording instruments have also been documented (MacHattie 1958; Hayes 1942). However, if these limitations are known and individual units are properly calibrated by qualified personnel and frequently checked for adjustment (Hardy et al. 1955), their accuracy can approach that of sling psychrometers. Of much greater value to the fire manager, however, is the record they provide of recent weather trends.

To make the instrument more useful in fire management, we modified conventional hygrothermographs (HTG) to record windspeed along with temperature and relative humidity. To describe their function more completely we call them hygrothermoaerographs (HTAG). An HTAG is shown in figure 1.

HYGROTHERMOAEROGRAPH CONSTRUCTION

Adaptation of hygrothermographs to record windspeed is not new. Our HTAG's represent refinement of a similar unpublished modification by Austin E. Helmers, developed in conjunction with hydrologic studies on the Priest River Experimental Forest during the period 1949-1951. Units patterned after this modification are currently in service at several weather stations in southern Idaho. Helmers also added a wind record pen to a 12-inch dual traverse recording rain gage as an aid in interpreting precipitation catch records.

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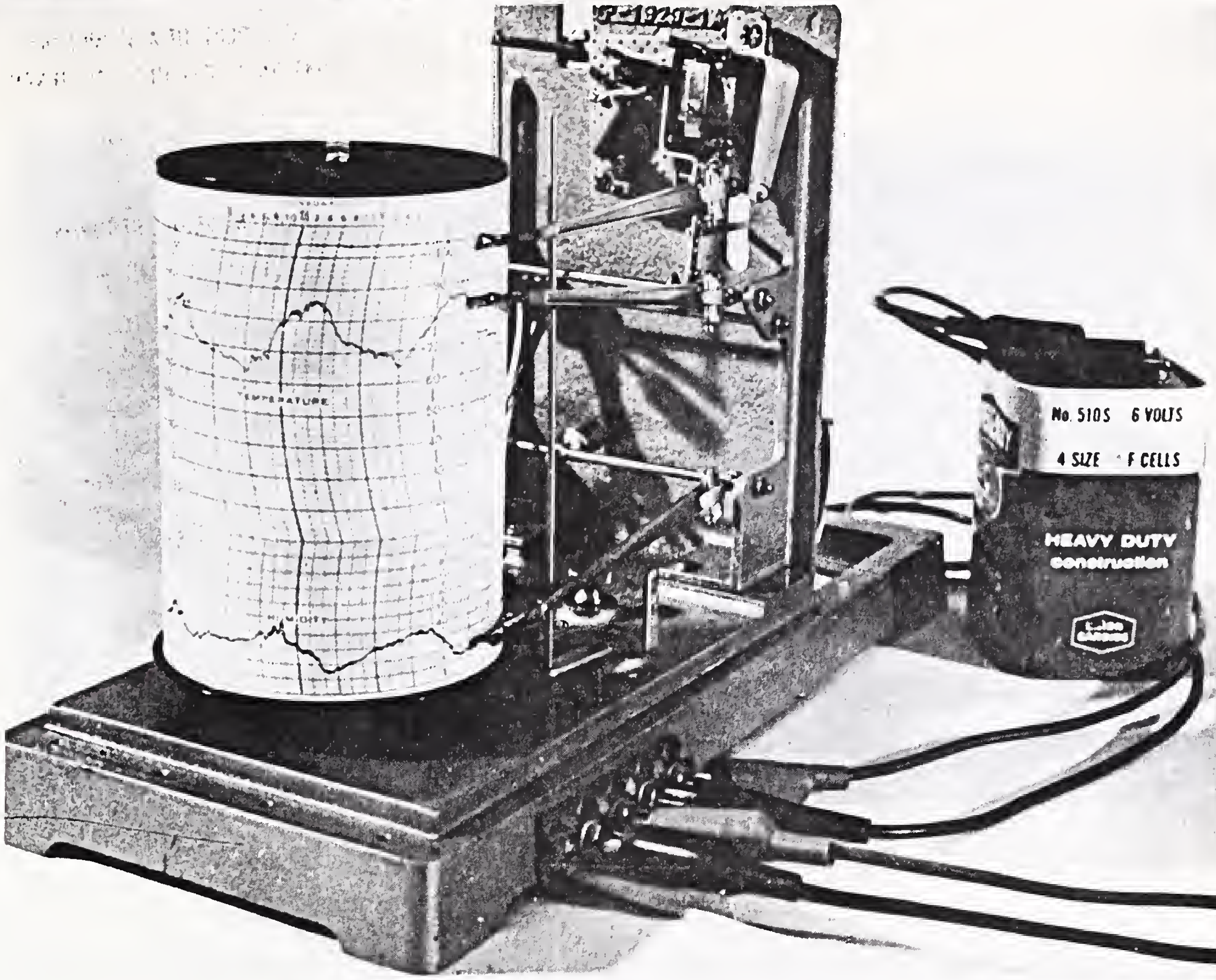

Figure 1.--A hygrothermoaerograph (HTAG). Upper arm records wind movement as transmitted by a contacting, totalizing-type anemometer. (Cover removed for photo only.)

Reigner (1964) described a method for adapting any drum-type recorder to obtain wind movement records. He proposed converting the hygrothermograph or rain gage to a wind movement recorder, rather than increasing the capability of these instruments.

Construction of an HTAG unit involves (1) modification of an anemometer; (2) construction and installation of the electrical circuitry; and (3) installation of an additional arm on a hygrothermograph. These tasks are well within the capability of most radio or electronic technicians employed by land management agencies. Necessary parts are available at a cost of approximately $9 from electronic supply houses. About 4 man-hours are required to make the conversion.

Anemometer Adaptation

The HTAG is designed for use with a contacting, totalizing-type anemometer. Both the Bendix[2] dial-totalizing type and the Belfort counter-totalizing type anemometers have been used successfully with our units (fig. 2). The extent of modification depends on the nature of readout desired. With the anemometers specified, it is possible to record every 1, 2, 5, or 10 miles of wind movement. For hygrothermographs with 24-hour charts we suggest obtaining a record of every 1 or 2 miles of wind. For those with weekly or monthly charts, a record of every 5 or 10 miles is more practical.

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[2]Mention of trade or brand names is solely for convenience in identification and does not imply endorsement by the Forest Service.

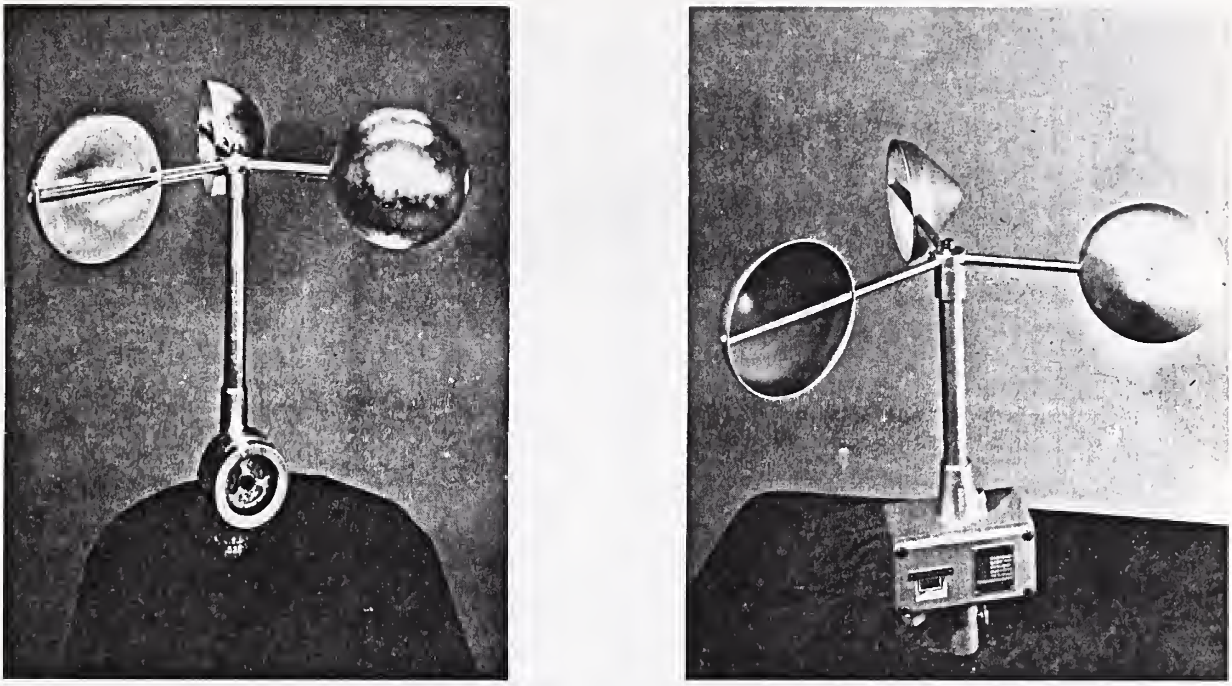


Figure 2.--Anemometers: dial-totalizing type (left) and counter-totalizing type (right).

We prefer a record of every 5 miles of wind on weekly charts. To obtain the desired readout, the unnecessary pins must be removed from the 1-mile contact, which is on the outer dial of the dial-type anemometer, and on the contact wheel of the counter-type anemometer. The pins can be removed quite easily with pliers. Desired wind readout is accomplished as follows:

Record desired	Modification required
1 mile	Leave all 10 pins intact
2 miles	Remove every other pin
5 miles	Remove all but two opposing pins
10 miles	Remove all but one pin

Most totalizing anemometers contain a 1/60-mile electrical contact in addition to the 1-mile contact. Only the 1-mile contact needs the modification described above. The two circuits can operate simultaneously if the HTAG is to be used at a fire-danger rating station. The National Fire-Danger Rating System currently prescribes that a 10-minute average wind value be taken at the standard observation time. A standard counter wired to the 1/60-mile contact circuit of the anemometer will allow it to be used for this purpose. The Bendix-Friez, Small Airways, Stewart, Chisholm, and Forester type contacting anemometers (U.S.D.A. Forest Service 1964) contain only a 1/60-mile contact circuit. For this reason, we did not consider their use with HTAG's.

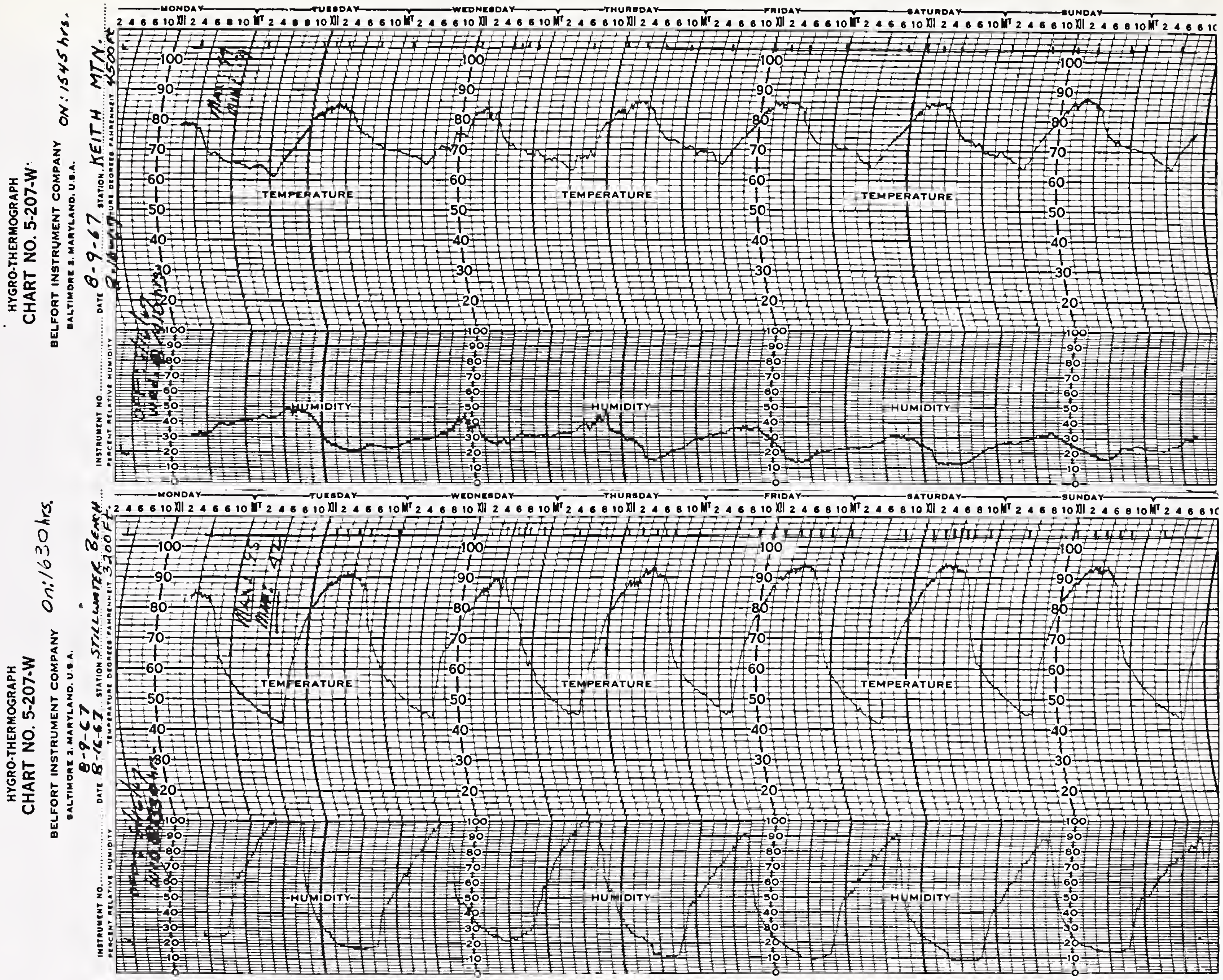
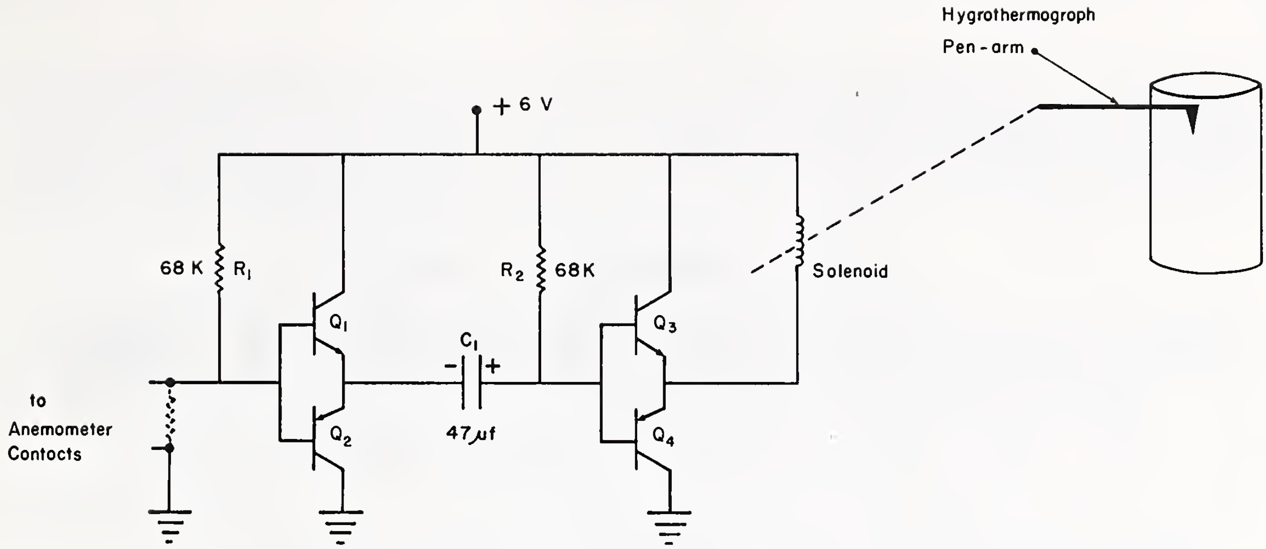


Figure 3.--HTAG charts showing windspeed (upper) trace in addition to temperature (middle) and relative humidity (lower traces).



Parts List

1 – Solenoid	–	D.C. Relay; 200 ohm w/silver contacts.(SIGMA-200 or equivalent.)
2 – Resistors	–	R_1 and R_2= 68k, ± 10%; 1/2 watt.
1 – Capacitor	–	C_1 = 47μf, 10 volt D.C.; ± 10%.
1 – Battery	–	6 volt, lantern type.
4 – Transistors	–	Q_1, and Q_3; NPN FAIRCHILD S7581 or equivalent. Q_2, and Q_4; PNP G.E. 2N1303 or equivalent.

Figure 4.--Wiring diagram and parts list for adapting a hygrothermograph to record air movement past a totalizing anemometer.

The Electrical Circuit

The electrical circuit is designed to represent each 1, 2, 5, or 10 miles of wind movement as a short vertical line on the HTAG chart (fig. 3). Sustained windspeeds of 30 m.p.h. can be legibly recorded on a weekly chart using 5-mile contacts.

An electrical contact is made each time anemometer cups travel a given number of revolutions. To record the revolutions, a solenoid is connected in series with the anemometer contacts and a battery power source. In ordinary use, actuation of the solenoid serves to trigger any of a variety of counters; for the HTAG, it moves a pen arm.

To prevent premature battery failure, we inserted a monostable vibrator in the circuit (fig. 4) to provide a 2-second current pulse to the solenoid when anemometer contacts close. If the contacts remain closed at the end of the current pulse because of cessation of wind, less than 0.1 milliampere of current is drawn from the battery through a large input resistor. An even larger resistor could be used to reduce battery drain, but some older anemometers are constructed with insulating materials that may provide a path for leakage of current to ground. This possibility is shown in figure 4 as a dotted-line resistor across the contacts. Since this insulation is actually a resistor of about 120 K ohms, a voltage-dividing network is formed at the circuit input. The result is a reduction in amplitude of the initiating voltage and a decrease in the time duration of the solenoid current pulse.

The solenoid was mounted on the bulkhead in the hygrothermograph. The remaining circuitry can be mounted on an insulated circuit board and also attached to the bulkhead (fig. 5). Type F, 6-volt lantern batteries showed no decrease in operational efficiency after 3 months of use. However, proper polarity (fig. 4) must be observed to prevent destruction of semiconductors during use.

Installing the Pen Arm and Solenoid

The additional pen and pen arm assembly can be obtained from the hygrothermograph manufacturer. Installation instructions are listed below and illustrated in figure 5.

1. Fabricate pen arm mounting bracket and shaft B from scrap hardware and attach to hygrothermograph bulkhead A. Use 1/8-inch diameter steel rod for the shaft.
2. Slip windspeed pen arm assembly C on shaft B and lock in place. Make sure the pen extends the same length on the chart as the other two pens.
3. Fabricate solenoid mounting bracket D from scrap hardware and attach to bulkhead A.
4. Attach solenoid E to bracket D. See figure 4 for solenoid specifications.
5. Solder small wire loop F to solenoid arm.
6. Using fine, solid wire (about no. 24) form connecting link G and loop one end through solenoid loop F.
7. Loop lower end of connecting link G through hole drilled in pen arm tongue H. The length of connecting link G should be such that the windspeed pen tracks above the 104° line on the HTAG chart.

Very carefully solder closed the loops at the ends of connecting link G. The loops should not be soldered to the points of attachment as freedom of movement is necessary for smooth operation of the pen arm.

EXAMPLES OF HTAG USE

Prescribed Fire

The HTAG effectively met weather data needs of our forest fire scientists in a recent study of fire use. The study plan required installation of two fire-weather stations at different elevations within a drainage. Prescribed fires were scheduled at many times during both day and evening throughout the available burning season. Burning during the summer required specific knowledge of when daytime winds moderated and when humidity began its nighttime rise. In addition, fire-weather forecasters requested that observations be taken 24 hours before each burn.

Personnel were not available to man our stations at the odd hours required by this schedule. Commercially available telemetering and automatic recording weather stations were priced beyond study means. Hygrothermoaerographs offered a reasonable alternative.

Our HTAG's were mounted in standard Cotton Region shelters and were read as necessary to provide weather data required for computation of National Fire-Danger Spread and Buildup Indices and to meet spot forecasting needs. Recording rain gages provided the necessary precipitation data. When conscientiously calibrated and periodically checked with an electric fan psychrometer, HTAG's proved to be our most valuable single tool for planning and timing experimental fires.

It was often desirable to ignite our fires to coincide with evening moderation of windspeed and rising relative humidity. Consistent daily patterns of wind, relative humidity, and temperature appeared within each general weather system. Favorable ignition conditions could be identified on HTAG records of days immediately preceding the proposed burn day. For example, if the preceding day's records showed opportunities for burning, and if the burn day's record and the spot forecast gave evidence that a similar pattern was developing, crews could then be mobilized. Costs and the number of canceled burns were thereby minimized.

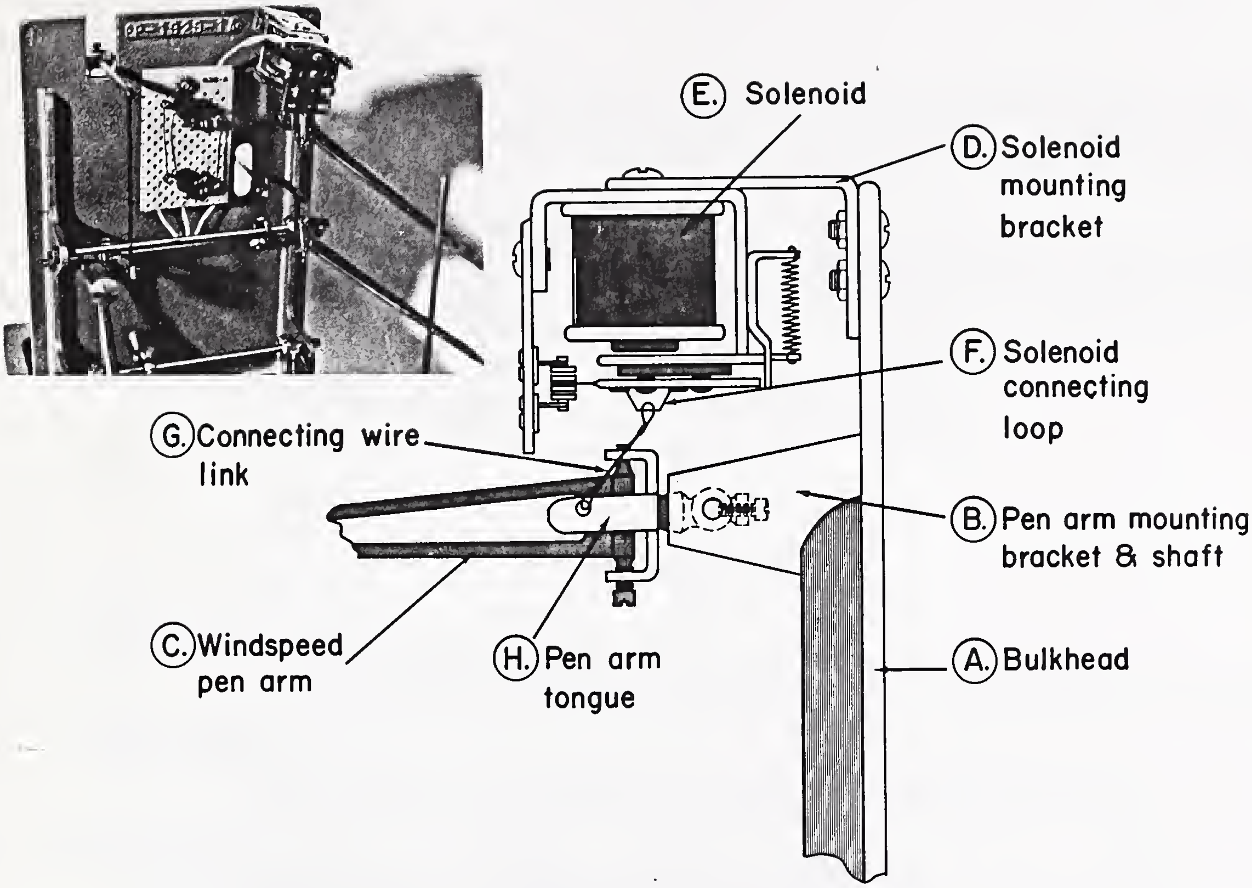


Figure 5.--Closeup view and sketch of the method of attaching solenoid and additional pen arm on a hygrothermograph bulkhead.

Other Applications

The success of the HTAG in providing continuous onsite records of windspeed, temperature, and relative humidity for prescribed fire operations suggests other applications of use to fire managers.

The HTAG can provide continuous weather data at the site of large wildfires to help fire behavior officers and fire-weather meteorologists relate existing synoptic conditions to possible fire behavior. In addition, the weather conditions existing at times of erratic fire behavior or rapid fire spread can be easily identified on the HTAG chart for postfire critiques.

The HTAG has several fire-danger rating applications. Foremost among them is its ability to provide a more complete record of fire danger than may be obtained from the once-daily observation of fire-weather factors. With the aid of the HTAG record, the fire manager can compare standard observation time values with maximum, minimum, and mean temperature and relative humidity trends, nighttime recovery patterns, and windspeed patterns. Hourly and diurnal variations of these weather factors are easily observed on the chart record. The importance of considering 24-hour records of this type when appraising fire danger has been cited by Barrows (1951) in his discussion of the thermal belt in the Rocky Mountains and more recently by Gwinner (1965) in his study of airmass as related to fire danger in the South.

When supplemented by precipitation records, National Fire-Danger Rating System Spread and Buildup Indices can be computed from the HTAG record. This capability is useful in maintaining fire-danger records during periods when an observer is not available.

A fire-weather climatology for a given area can be developed by means of a combination of the HTAG and recording rain gage. Such a record is valuable in fire-weather forecasting and fire control planning. With proper interpretation it can form the basis for selection of fire-danger station sites.

This discussion on the HTAG has been limited to its uses in fire management. Workers in other fields may recognize additional applications.

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